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ABSTRACT

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Running head: ATTITUDES TOWARD MATHEMATICS

EFFECT OF GENDER, ACHIEVEMENT IN MATHEMATICS, AND GRADE LEVEL ON ATTITUDES TOWARD MATHEMATICS

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Paper presented at the Annual Meeting of the
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Little Rock, Arkansas
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ABSTRACT

The effects of gender, math achievement and grade level on attitudes toward mathematics were examined by use of an inventory, Attitudes Toward Mathematics Instrument. Subjects were 803 bilingual, middle and high school students. The data were analyzed using a multivariate factorial model with 4 factors of Mathematics Attitudes as dependent variables (self-confidence, value, motivation, and enjoyment of mathematics) and 3 independent variables (gender, math achievement, and grade level). A 2-way significant interaction of achievement by grade level was found. The interaction was found to be significant for value, motivation, and enjoyment of mathematics at all grade levels. "A" students scored higher than all other students on the three factors from 7th through 10th grade and in motivation in students in 11th and 12th grade. For value, failing students were lowest in 7th through 10th grade. A similar relationship of letter grade to motivation was found in the hierarchy for "B to D" students in 7th and 8th grade. For enjoyment, failing students were lowest in 7th and 8th grade, B and C students scored higher than D and F students in 9th and 10th grade, and A and B students were highest in 11th and 12th grade.

Effect of Gender, Achievement in Mathematics, and Grade Level on Attitudes Toward Mathematics

Introduction

The decline of mathematics scores on the Scholastic Aptitude Test has been widely publicized (Goldberg & Harvey, 1983). The Third International Mathematics And Science Study (1998), TIMSS, has reported that as students increase in age group from grade four to grade twelve their math scores decline. That presents a problem in our modern society that has become increasingly dependent upon technology, science, and research, mathematics has become critical in the preparation of students for future careers and for the security and progress of the nation. There has been considerable concern about mathematics instruction since the "Space Race" of the 1950's, a concern has only increased in the last decade as we have entered a new technological age. Mathematics is continuously developing and becoming ever more specialized, which makes it more difficult to develop a curriculum that includes more students in K-12 education. Complicating this is disagreement about methodology across content domains, with some maintaining that content disciplines are unique and that teaching strategies must also be unique. The opposite view is that universal methods exist regardless of the content domain (Reigeluth, 1987). However, the most predominant approach in recent years, regardless of theoretical orientation of curriculum designers, is an emphasis on authentic or "real-world" applications. This is further complicated by professional disputes over constructivism versus direct instruction.

Today, classroom instruction is often a mixture of Skinnerian behaviorism and Piagetian or Vygotskyian epistemology influenced by postmodern and connectionist theories (Collins & Duguid, 1989; Bednar, Cunningham, Duffy, & Perry, 1991; Shepard, 1991; Hlynka & Belland, 1991; Clancey, 1992). The national standards for mathematics are predicated on the belief that students should engage in math activities that are relevant to daily living. However, many educators and school patrons see this as a culmination rather than something intrinsic to math instruction. In recent years we have learned that children do not simply internalize what teachers tell them in classrooms. Students attempt to make sense of new information based on meanings they personally construct. And fundamental to all of this is the students' attitudes about mathematics.

Research shows that attitudes toward mathematics are extremely important in the achievement and participation of students in mathematics (Shashaani, 1995). Gallagher and De Lisi (1994) showed a positive relationship between performance on standardized mathematics tests and positive attitudes toward mathematics. Attitudes can predict final mathematics course grade and are correlated with continuation in advanced mathematics courses once enrollment becomes optional (Thorndike-Christ, 1991).

Due to the social context and other intervening variables, differences in attitudes exist by gender, ethnicity, cultural background, and instructional methods (Murphy & Ross, 1990; Hollowell & Duch 1991; Huang, 1993; Leder, 1994). Recognizing the importance of attitudes, there is an increasing awareness of the need to examine attitudes and consider possible methods of intervention. The development of a positive attitude toward subject matter is probably one of the most prevalent educational goals.

Previous Research

Math anxiety is directly related to previous school mathematics performance as well as the attitudes developed during those prior mathematical experiences (Hauge, 1991). Terwilliger and Titus (1995) reported attitudes are inversely related to math anxiety. Nearly as many students who decide to major in science, mathematics, or engineering after their sophomore year of college as high school sophomores with similar intentions, indicating that attitudes can be affected (Hoffer, 1993). It is clear that knowledge about the importance of math is important, as reported in The Longitudinal Study of American Youth (1991), which showed that 28 percent of all seniors who were not enrolled in a mathematics or science course did not believe advanced mathematics was required for their future plans. Of the 12th-grade students who planned to become scientists, less than two-thirds believed they needed specific advanced mathematics in high school. Among 8th-grade students, 57 percent said they looked forward to mathematics classes; 90 percent believed mathematics to be important to their futures.

Self-confidence or self-efficacy is a good predictor of success in mathematics (Goolsby, 1988; Randhawa et al. , 1993)). Changes at the affective and achievement levels have more effect on participation in mathematics that those aimed at cognitive levels (Linn & Hyde, 1989). Clearly, the support and actions of parents and teachers are critical in shaping attitudes (Kenschaft, 1991; Dossey, 1992; Chang, 1990

Attitudes toward mathematics may be related to achievement and ability in mathematics but not to temperament or other personality variables (Dwyer, 1993). Teachers' attitudes are significantly related to student attitudes but not to achievement, but the effect of teachers' attitudes on students' attitudes is cumulative. Students make higher achievement gains if they had a sequence of 3 teachers with favorable attitudes towards mathematics.

The cultural context is important in creating gender differences (American Association of University Women, 1992; Hanson, 1992; Gill, 1994). Students stereotype careers by gender and consider science professions to be for males; however, neither boys nor girls are aware of the importance of math and science in careers (Pettitt, 1995.). Stipek and Granlinski (1991) found that girls tend to believe that females are inferior in math and that poor performance is because of a lack of ability instead of lack of effort. While the literature shows that attitudes toward mathematics are important, there is a paucity of research about the different factors that influence the attitudes toward mathematics or an understanding of how and why they change over time.

Method

Subjects

The subjects were 803 middle and high school students from a private, bilingual college preparatory school in Mexico City, Mexico, accredited by The Southern Association of Colleges and Schools. The high school has approximately 720 students; each grade has approximately 180 students. The middle school has approximately 450 students; each grade has 150 students. The students are bilingual, speaking English and Spanish. The school population consists of Mexicans, Mexican-American (born in Mexico with at least one American parent), Americans (children with parents working for international companies of for the United States Embassy), and other nationalities (children with parents working for international companies or different embassies). Most of the students were from high-income families. Four hundred thirty seven subjects were boys and 366 subjects were girls from 7th to

12th grade. The subjects were enrolled in mathematics classes conducted by ten mathematics teachers. Intact classes were used in the sample.

Of the 437 boys, 141 were in 7th or 8th grade, 157 were in 9th or 10th grade, and 139 were in 11th or 12th grade. Fifty-two percent of the boys were Mexican, 15% were American, 14% had dual citizenship (having one American parent), 8% were from Latin American countries, 2% were Europeans, 5% were Asian, and 5% reported other nationalities. Four of the boys did not report their ethnic background. Of the 366 girls, 125 were in 7th or 8th grade, 131 were in 9th or 10th grade, and 110 were in 11th or 12th grade. Fifty-two percent of the girls were Mexican, 16% were American, 15% had dual citizenship (having one American parent), 6% were from Latin American countries, 1% was European, 5% were Asian, and 5% reported other nationalities. Two of the girls did not report their ethnic background.

Materials

The Attitudes Toward Mathematics Inventory (ATMI) is a 40-item scale. The items were constructed using a Likert-format scale of five alternatives for the responses with anchors of 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, and 5: strongly agree. Eleven items of this instrument were reversed items. These items were given the appropriate value for the data analysis. The score was the sum of the ratings.

A Student's Demographic Questionnaire was also used. This questionnaire consisted of five questions. The purpose of these questions was for identifying the gender, grade level, current grade in mathematics, and nationality-ethnic background of the student.

Procedure

The mathematics teachers administered the ATMI and the Student's Demographic Questionnaire to the subjects during their classes. Directions were provided in written form, and students recorded their responses on computer scannable answer sheets.

Results

Tapia (1996) found a four-factor solution from an exploratory factor analysis with maximum likelihood method of extraction and a varimax, orthogonal, rotation. The names for the factors reported in Tapia (1996) were Self-confidence, Value of Mathematics, Enjoyment of Mathematics, and Motivation. Based on that factor analysis, the 40 items were classified into four categories each of which was represented by a factor. A composite score for each category was calculated by adding up all the numbers of the scaled responses to the items belonging to that category.

The data were analyzed by using multivariate factorial model with the four factors as dependent variables: (1) Self-confidence , (2) Value, (3) Enjoyment, and (4) Motivation and three independent variables: (1) gender, (2) grade level, and (3) achievement in mathematics class. Multivariate analysis of variance (MANOVA) were performed by using SPSS.

The linear model was written as,

SC VAL ENJ MOT = G + GLV + ACH + G*GLV + G*ACH + GLV*ACH + G*GLV*ACH

where

SC = Self-confidence

VAL = Value of mathematics

ENJ = Enjoyment of mathematics

MOT = Motivation

G = Gender

GLV = Grade level

ACH = Achievement in mathematics class

Data were analyzed testing for interaction effect and main effect at the .05 level. Data analysis indicated that the three-way interaction effect of the three variables G*GLV*ACH on the four dependent variables Self-confidence, Value, Enjoyment, and Motivation was insignificant (Wilks' Lambda F= .958, $p < .54$,). Hence, it was concluded that there was not enough evidence to indicate a three-way multivariate interaction.

The analysis showed that the two-way interaction effect of GLV*ACH was significant as were the main effect of gender, grade level, and achievement. Table 1 shows F, p, and eta squared values for the interactions and the main effects. The eta squared values for Gender, Grade level, and GLV*ACH had small effect sizes, and the eta squared value for Achievement had a medium effect size. The GLV*ACH interaction was disordinal and therefore the significant main effects were not further analyzed. Table 2 shows that the interaction of grade level by achievement was significant for value, motivation, and enjoyment of mathematics.

The grade level by achievement interaction effect was analyzed using a simple main effects analysis for value, motivation, and enjoyment of mathematics. Table 3 shows that Achievement levels influenced value, motivation, and enjoyment at all grade levels. The F tests the effect of letter grade. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Table 1

Interaction and Main Effects Tests for SC VAL ENJ MOT = G + GLV + ACH + G*GLV + G*ACH + GLV*ACH + G*GLV*ACH

Effect	Value	F	Hypothesis df	Error df	Sig.	Eta Squared
G	.977	4.445	4.000	770.000	.001	.023.
GLV	.954	4.587	8.000	1540.000	.000	.023
ACH	.685	19.410	16.000	2353.026	.000	.090
G*GLV	.984	1.571	8.000	1540.000	.129	.008
G* ACH	.969	1.514	16.000	2353.026	.086	.008
GLV*ACH	.928	1.830	32.000	2841.215	.003	.019
GLV*G*ACH	.961	.958	32.000	2841.215	.535	.010

Table 2

Grade Level by Achievement Interaction Tests of Between-Subjects Effects

	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
SELFCONFIDENCE	1378.107	8	72.263	1.639	.110	.017
VALUE	1000.144	8	125.018	3.328	.010	.033
MOTIVATION	895.268	8	111.908	2.075	.036	.021
ENJOYMENT	284.600	8	35.575	2.830	.048	.020

Table 3

Univariate Tests of Simple Effects of Achievement within Grade Level

GRADELVL	Source	Sum of Squares	df	Mean Square	F	Sig.
Dependent Variable: VALUE						
$7^{th} - 8^{th}$	Contrast	1004.886	4	251.222	6.646	.000
	Error	29784.691	788	37.798		
$9^{th} - 10^{th}$	Contrast	1691.907	4	422.977	11.191	.000
	Error	29784.691	788	37.798		
$11^{th} - 12^{th}$	Contrast	807.086	4	201.772	5.338	.000
	Error	29784.691	788	37.798		
Dependent Variable: MOTIV						
$7^{th} - 8^{th}$	Contrast	3495.416	4	873.854	16.056	.000
	Error	42888.045	788	54.426		
$9^{th} - 10^{th}$	Contrast	3969.059	4	992.265	18.231	.000
	Error	42888.045	788	54.426		
$11^{th} - 12^{th}$	Contrast	2071.687	4	517.922	9.516	.000
	Error	42888.045	788	54.426		
Dependent Variable: ENJOY						
$7^{th} - 8^{th}$	Contrast	811.132	4	202.783	10.798	.000
	Error	14798.447	788	18.780		
$9^{th} - 10^{th}$	Contrast	1442.177	4	360.544	19.199	.000
	Error	14798.447	788	18.780		
$11^{th} - 12^{th}$	Contrast	648.778	4	162.194	8.637	.000
	Error	14798.447	788	18.780		

The significant simple main effects of achievement were further analyzed by pairwise comparisons. Table 4 shows estimated marginal means of value, motivation, and enjoyment for achievement within grade level.

For students in 7^{th} – 8^{th} grade, "A"students scored higher in Value than all other students and failing students scored significantly lower than all other students. For students in 9^{th} – 10^{th} grade, "A" students scored higher in Value than all other students, failing students scored significantly lower than all other students, and "C" students scored significantly higher than "D" students. "A" and "B" students in 11^{th} – 12^{th} grade scored significantly higher in Value than "C" students in the same grade level.

In motivation, "A" students in 7^{th} – 8^{th} grade scored higher than all other students in the same grade level. For students in 7^{th} – 8^{th}, a similar relationship of letter grade was found in the hierarchy for "B to D" students in motivation. For students in 9^{th} – 10^{th} grade, "A" students scored higher than all other students and failing students scored significantly lower than all other students. For students in 11^{th} – 12^{th} grade, "A" and "B" students scored higher than all other students and "A" students scored higher than "B" students.

For students in 7^{th} – 8^{th} grade, "A" students scored higher in enjoyment than all other students and failing students scored significantly lower than all other students. For students in 9^{th} –10^{th} grade, "A" students scored higher in enjoyment than all other students, and "B" and "C" students scored higher than "D" and "F" students. For students in 11^{th} – 12^{th} grade, "A" and "B" students scored higher than all other students.

Table 4

Estimated Marginal Means

		VALUE	MOTIVATION	ENJOYMENT
7th – 8th	A	42.8075	36.6106	18.0738
	B	40.0289	32.9539	15.5435
	C	39.9286	29.3631	14.3810
	D	37.7500	25.1667	13.3333
	F	29.2500	16.0000	7.0000
9th – 10th	A	41.2587	37.1702	18.9172
	B	37.4188	31.5290	15.7318
	C	38.2525	30.4556	14.9232
	D	35.6382	29.0285	12.4912
	F	29.5341	22.0795	10.0568
11th – 12th	A	40.5436	35.9128	17.6349
	B	39.9791	33.1812	17.5317
	C	36.0126	28.6780	14.7626
	D	38.1875	29.7361	14.3194
	F	37.2500	27.6667	12.7083

Conclusions

The multivariate data analysis indicated that the three way interaction effect of the three variables Grade Level*Gender*Achievement to the four dependent variables Self-confidence, value, enjoyment, and motivation was insignificant. The data suggested that there was enough evidence to say that the two-way interaction effect of Grade Level*Achievement was significant, as were the main effect of gender, grade level, and achievement.

The Grade Level*Achievement was analyzed and found to be significant for value, motivation, and enjoyment. The grade level by achievement interaction effect was analyzed using a simple main effects analysis of achievement within achievement for value, motivation, and enjoyment of mathematics. Achievement levels influenced value, motivation, and enjoyment at all grade levels.

The significant simple main effects of achievement were further analyzed by pairwise comparison using the Sidak adjustment for multiple comparisons. There was enough evidence to show that "A" students scored higher than all other students on the three factors from 7th through 10th grade and in motivation in students in 11th and 12th grade. For value, failing students were lowest in 7th through 10th grade. A similar relationship of letter grade to motivation was found in the hierarchy for "B to D" students in 7th and 8th grade. For enjoyment, failing students were lowest in 7th and 8th grade, B and C students scored higher than D and F students in 9th and 10th grade, and A and B students were highest in 11th and 12th grade.

It is important to note that the subjects in this study were atypical because they all attended a private school, were from privileged backgrounds, and from high socio-economic families. The school was patterned on an American high school curriculum and organization, but the majority of students were Hispanic and there were far fewer Anglo and Asian students.

Applications and Implications

While there is a widespread concern about the performance of students in mathematics, most attention to the subject has been in the form of higher expectations, testing programs and revised methodologies, such as the NCTM standards that have provoked considerable controversy. Clearly, there has been insufficient attention to the attitudes of students about mathematics, although there has been much attention to their performance, errors and test scores. As a political or pedagogical issue, improvement is often debated as simply matter of methodology. Rather than only concentrating on changing the textbook or the approach, perhaps there are more significant and subtle factors inherent in the attitudes of students themselves that must be more seriously investigated and taken into account.

If a student's self-perceived ability is critical to success and a predictor of failure or achievement, then concern about students' attitudes must be elevated. Much more needs to be learned about how attitudes are formed and altered, and the best techniques for intervention and stimulation of positive self-efficacy. Consequently, much more must first be done in the development of valid and reliable instruments to conduct the necessary research. Bandura (1981) argued that judgments of self-efficacy are task specific, making them better predictors of success in a particular domain. Therefore, continued research in the area of attitudes toward math is essential if students are to be understood and attitudes altered. The use of a valid and reliable instrument for making determinations about attitudes is a requirement for such research.

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